THE THEORY AND PRACTICE

OF

SANITATION IN COUNTRY PLACES,

INCLUDING THE

BACTERIOLYTIC TANK SYSTEM.

BY

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THE THEORY AND PRACTICE OF SANITATION IN COUNTRY PLACES

(Including the Bacteriolytic Tank System).

Everyone is familiar with the changes produced in the dry arid land by a week of soaking rain and genial warmth. What was formerly a desert of bare barren sand is now a field of living green. Trees, dreary and leafless since last autumn, have burst their buds and donned their leafy mantles. The whole earth is covered with varied forms of beauty and wondrous varieties of color, and is redolent with sweet odors. By-and-by field and vineyard and garden will be full of rich fruits, and the forests will be heavier with timber.

But these visible changes are not the only results of plant growth. There are others, less obvious, but not less wonderful. The living substance contained in innumerable plant cells has been employed in converting certain constituents of the soil into hundreds of " principles " which, though apparently of no direct use to the plants themselves, are nevertheless of unspeakable benefit to mankind. When one considers that from cinchona bark over 60 distinct substances have been separated, and from opium about 40, many of which are of great chemical complexity, one realises something of the enormous extent and variety of the processes taking place that depend upon the relations between the soil and plant life.

Apart from the sea—and man shall no more live by fish alone than by bread—we depend upon the soil, directly or indirectly, for all our food and clothing, our subsistence and our comfort. The necessaries, the luxuries, and the adornments of existence are found in the country. All theories of the origin of the race place the first of mankind in rural surroundings. " God Almightie," says Bacon, " first planted a Garden. And, indeed, it is the purest of Humane pleasures. It is the greatest Refreshment to the Spirits of Man ; without which, Buildings and Pallaces are but Grosse Handy-works."

> God made the country, and man made the town ;
> What wonder, then, that health and virtue, gifts
> That can alone make sweet the bitter draught
> That life holds out to all, should most abound
> And least be threatened in the fields and groves.

We are not now concerned with the mental or moral privileges that a garden or a country life confers ; our subject is the lower one of health alone. The only light that will illumine it will be the dry light of Science.

"God the first garden made; the first city, Cain." Cain is the patron saint, or patron sinner, of all such as build cities. They have no thought for their neighbor. They are not their brother's keeper. Towns are after-thoughts—the requirements of an artificial civilisation. The huddling together of human beings within a city was doubtless due at first to the necessities of defence. Later on, towns arose at the seat of mines because of the advantages connected with manufacture, and around seaports for the convenience of commerce. Social life and health have never received so much consideration as defence and commerce. Towns always had their drawbacks and disadvantages. Architects and health authorities have ever been concerned about open spaces and vegetation between houses, about fresh air and sunlight in and around dwellings, about food and water, and the removal of refuse. Dwellers in cities have often to pay dearly for their so-called privileges, not only in the tale of lives they contribute to epidemics of preventable diseases, but in the general shortening of the average human life.

It is notorious how city customs and fashions have influenced social life in the country. And the same is true of the adjuncts of social life. What in the town is a necessary evil is not only tolerated in the country, but is looked upon as "the correct thing." In the country one cannot unbend one's self from the town twist. A builder finds it impossible to cast away his town-bred ideas, and builds underground kitchens and coal cellars in his country mansion, being so long accustomed to build houses with a minimum of area that, when he has unlimited space at his disposal he fails to appreciate the advantages of the boon. It is doubtful if the invention of the telephone and the electric car, which ought to obviate the necessity of the crowding together of men for commercial purposes, will be able to break down habits that have become part of our being. Customs unfortunately persist after their necessity or utility has ceased.

The problems of health in cities are complex and difficult. All systems of city sanitation are expensive and unsatisfactory. Scientific hygiene, *i.e.*, sanitation by the employment of the ordinary processes of nature, can be carried out only in the country, or in places where each house has its garden or small plot of land surrounding it. Dr. Poore, a writer to whom reference will again be made, says—"Sanitation is purely an agricultural question, and in the country, where every cottage has, or should have, its patch of garden, there ought to be no difficulty in the daily removal of refuse from the house, and in applying it to agricultural purposes, without any risk of contaminating the water supply. Given the patch of garden, the only thing necessary to bring about this, the only complete form of sanitation, is the will to do it—the will, that is, to do a profit to one's self without the possibility of damaging one's neighbor. This, unfortunately, is rarely forth-

coming, in spite of the Christian religion and the Education Act, and we go on, even in country places, polluting our streams and wells, with our minds agitated, as well they may be, as to when our water will become too poisonous to drink, and where we shall turn for a pure supply in the future. Sanitation is a purely agricultural and biological question. It is not an engineering question, and it is not a chemical question; and the more of engineering and chemistry we apply to sanitation the more difficult is the purifying agriculture. This, at least, has been the practical result in this country."

The author speaks of England. Shall we find the conditions different in other countries? Let us inquire into the facts and factors of natural or biological sanitation—that is, purification by means of plants and animals, as distinguished from chemical purification—and try to answer the question.

Reference has been made to the growth of plants. As a rule plants by their roots take up water with certain substances in solution in it. This sap, passing to the leaves, comes into contact with the oxygen of carbon dioxide that has been taken in by the leaves. The result, under the influence of sunlight, is the formation of starch. This in turn is converted into a soluble substance from which the wood, bast, cork, and all the tissues composing the plant are derived. The total effect of these processes on the earth and air is (1) to increase the amount of oxygen and decrease the amount of carbon dioxide in the air; (2) to lessen the amount of animal and mineral substances in the soil. The first process is called purifying the atmosphere, because it restores the balance of oxygen which has been disturbed by the breathing of animals; the second process is spoken of as a purifying of the soil, because the emanations from decaying animal material would prove harmful to living animals if the products of decomposition were not utilised by plants. When we speak of purification it will be noted that we speak from the point of view of the requirements of animals, not of plants.

The obvious or evident plant-growth, however, is, as has been said, only a small part of the processes that go on; and the plants we see are but a small portion of the whole as regards number and variety. Every cubic inch of mould teems with myriads of minute plants known as germs, microbes, micro-organisms, or bacteria. They are concerned in the processes of breaking up organic matter—that is, material derived from plants and animals—and thus making it available as food for the green plants referred to. Besides these there are other microbes, not long known, that are employed in making the free nitrogen in the soil available as the direct food of certain kinds of plants. It has been found that the roots of some kinds of plants—especially leguminous plants like peas, clover, and vetches—have swellings on them which, when examined, are found to be made up of tissues containing numerous

bacteria. The process of planting these collections of bacteria in soil in which they are not naturally present is known as "inoculating the soil." Finally, there are plants known as saprophytes, on account of their feeding directly upon decaying organic matter. As examples of these we may mention many fungi.

Thus the soil, as the abode of all these plants, is fitted to deal with all sorts of organic refuse. Plants die. Animal eats plant or other animal; the refuse, dung, or undigested food is composed of animal and vegetable matter. The animal itself dies, falls on the soil and is decomposed. Thus garbage, the dung of animals, animals themselves, and human excreta are all transformed by decomposition, a process which is essentially a fermentation; and the products of this decomposition in the soil are utilised by plants for their life and growth. We have seen that the process of transformation into plant substance gives us food and purifies the atmosphere.

This is not all, however. This same soil protects our water supplies. For it has been found that only mould, or the superficial soil, possesses the transforming power referred to. The subsoil, which contains little if any of the sort of germ life mentioned, is ineffective as a biological purifier, though, by retaining particles of refuse, it acts to a certain extent as a mechanical filter. The result is that if organic matter is buried deeply, by which we mean below the mould or surface soil, it may remain unchanged for months or even years. Privy pits dug deep in the subsoil have been covered up, and after many years they have been reopened, and their contents have been found as fresh looking, as offensive, and as dangerous as when they were closed up. The same thing is true of dead bodies. Hamlet asked, "How long will a man lie i' the earth ere he rot?"; and the gravedigger said, "He will last you some eight or nine year." This obviously refers to the long-established practice of deep burial. A body buried in mould 3ft. deep or thereby will in 12 months' time show nothing but the bones. When organic matter is buried deeply it may, instead of remaining unchanged where it was buried, be carried by water—either mechanically or in solution—to great distances, even miles, underground, and may thus contaminate wells in the neighborhood. Herein is found the explanation of how cesspools become dangerous to a community. Their contents soak into the surrounding subsoil. A proper cesspool—that is, a water-tight one—is a curiosity that is seldom met with. There is a very common idea, and a widely distributed one, that a cemented cesspit is much improved in its usefulness and gives less trouble if a few holes be driven through its bottom or sides with a crowbar.

To the mechanical and biological actions of the superficial soil or mould as a filter we must look for the protection of our water supplies. So long as dead animal and vegetable matter decomposes on or in the mould, so long will the decomposition be complete and the resulting

products harmless. There need be no fear of applying too much dung to the mould or of exhausting its powers. The more it is given to do the more it does, and the more it becomes capable of doing, so long as it is "cropped."

Animal matter and other nitrogenous material in contact with the soil undergoes decomposition without offending our sense of smell or injuring our health. This decomposition, as we have seen, is effected by the visible and invisible plants of the mould. The conditions under which this takes place are as follows :—(1) A certain amount of air in the soil is necessary, *i.e.*, the soil should be porous, and not water-logged ; (2) a certain amount of moisture is essential, preferably about 33 per cent. ; (3) the active processes are best carried out at a temperature of 50°-55° C. (122°-131° F.).

It will be seen that the circumstances in this country are much more favorable to complete and speedy decomposition than they are in England. No disinfectants should be used ; they sterilise the soil by killing the active microbes. Perfect decomposition is shown by the absence of offensiveness. Smell, whether from large fermenting heaps of manure or small quantities of excreta or urine, means waste of useful material. It does not necessarily mean danger. The ammonia from a dung heap is the same substance that we buy in bottles for domestic purposes. On the other hand, absence of smell does not necessarily imply safety. Some of the conditions most dangerous to health are associated with no offensiveness.

As has been said, the power of the soil to decompose manure, excreta, and garbage increases by use. One cannot state a limit, but it has been found that it is possible to put as much as 200 tons of stable manure per annum on an acre of market garden land near London—the average being from 60 tons to 80 tons. The soil in this country could take all that quantity and even more. All this is utilised by the crops grown on the land.

As regards excreta, it has no doubt often been observed that when these are deposited on or in the mould decomposition takes place rapidly and without offensiveness. One has only to study the sanitary methods and results of that most cleanly of all domestic animals, the cat, in order to be convinced of this. Other conditions being similar, it makes no difference whether the excreta are taken to the earth or the earth taken to the excreta. The immediate treatment can be begun in an earth closet.

THE DRY EARTH CLOSET SYSTEM.

The Closet.—In 1874 the State Board of Health of Massachusetts published a report on the health of farmers and farmers' families in that State. It was the outcome of a series of very extensive investigations made by country doctors in response to questions asked by the

Board. The following quotation from the report refers to a state of affairs that is, unfortunately, not confined to Massachusetts :—" As to country privies, one of our correspondents has well said they are ' a disgrace to civilisation.' The common country privy, unventilated, except by the door, standing over a reeking mass of corruption, either contained in a vault or lying upon the surface of the ground, a place foul and pestilential beyond description—this must be the daily resort of every member of the farmer's family. If it adjoins the house, its poisonous odors penetrate to the living rooms ; if standing several rods away, as it frequently does, an exposure to the weather is involved in reaching it. In either case, in winter it is frightfully cold, and its use involves a chill, which, to women and children especially, coming from warm rooms, is a potent cause of disease. Undoubtedly, the constipation which is so general among country women is, in great part, due to the dread of going to this abominable place."

Something requires to be said about school closets. The Parliament of the Commonwealth of Pennsylvania in 1893 passed an Act " For the better protection of the health and morals of school children." This law requires the board of directors of the school to provide suitable and convenient closets, separate for boys and girls, and unless placed at a remote distance from each other the approaches shall be separated by a close fence not less than 7ft. high ; and it imposes on the directors the duty of keeping the closets clean, comfortable, and healthful. Neglect of these duties makes the directors liable to be removed from their office by the Court of Quarter Sessions. The State Board of Health calls attention to this Act in a circular to school directors, and in that communication some very plain things are said regarding school privies. " A shameless disregard of the proprieties of life and the allowance of the vilest accumulations of filth, coupled with inconvenience and rudeness of accommodations, characterise the conveniences provided by too many school boards.

" It must not be supposed that, in the opinion of this Board, school directors and controllers are in any considerable degree more negligent than their constituents in this matter. The condition of the sanitary, or more strictly unsanitary, arrangements for the school is simply too often a reproduction of those which exist at the home."

The Board says the privies should be absolutely distinct for each sex—" out of sight and out of mind " each from the other ; and they recommend the adoption of the earth closet in preference to the dangerous privy vault. The Board also calls special attention of the school boards to the fact that they cannot draw their annual grants from the State until the President of the School Board has certified that the requirements of the Act for the thorough disinfection and cleaning of the outhouses have been fully complied with.

The condition of affairs in the State of New York is thus referred to by a well-known sanitarian and former member of the New York Board of Health :—" In addition to the well-known dangers attending the neglected accumulations of privy-vaults few things are more destructive to health and comfort than dependence on one of these dreadful outbuildings. A visit to one of them involves an amount of exposure in cold weather which even strong men have reason to dread. In the case of women, children, and invalids, what can be worse than a plunge out of doors in cold or stormy weather, usually without the precaution of extra clothing or overshoes, for a visit to the foul shrine of cloacina ? The neglect of regular attention to the calls of nature, which the dread of this exposure induces, tends to encourage women and children in disregarding them as long as possible, until the evils inevitably attendant upon the habit of constipation—much too prevalent in this country—are induced and confirmed. The head of a family who makes no better provision for the needs of his household neglects the most obvious of his sanitary duties."

The closet may be at some distance from the house, with which it may be connected by a trellised way covered with creepers. The path to it should be dry in all seasons and at all times. In general structure it may resemble a water-closet. (See Fig. 1.*) Ventilation is provided for by an inlet ventilator, low down, which can be easily opened and closed from within, and by an outlet above the door. The requisites are a pail under the seat, a box to hold the earth, and a small scoop to spread the earth over the excreta. The seat should not be more than 14in. high ; the opening should be oval.† It has been found that constipation and other evils are induced or aggravated by high closet seats. It is unnatural that the feet should be off the ground, and the squatting position has been found to be the most hygienic. In some countries, such as France, ordinary closets have no seats or pedestals.

The Pail should be light and manageable, and so shaped as to be easily kept clean. A convenient form (see Figs. 2 and 3) is a cylindrical pail of galvanized or enamelled iron, 13in. in diameter and 12in. high, with a handle attached at some distance below the lid to allow a rim to be used, if desired, when carrying it away. The pail should fit as closely as possible under the seat, between guiding runners or by some other contrivance.

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* The cost of a single closet complete is £4 15s. ; if supplied by the hundred, £4.

† Dr. Groff, of the Pennsylvania State Board of Health, says :—" The hole in the seat should be long from front to back, but narrow from side to side, never made circular, with a pair of dividers, as a country carpenter will invariably make it unless otherwise instructed. The proper dimensions are 11in. x 4in. The edges should be moderately bevelled. The shape will make the act of relief much easier, and tend greatly to prevent that painful disease, hæmorrhoids."

The simplest arrangement in the closet is to have a movable seat, which can be placed directly on the top of the pail. This allows of seats with various sizes of apertures to be used if so desired. The next simplest method is to place the pail in a corner, and to have a seat so hinged to one side of the closet that it rests, when, level, on a bracket on the adjacent side. This obviates the necessity of a "box"—a structure that is objectionable for several reasons. It also does away with the necessity of having an opening at the back of the closet through which to remove the pail. Should the seat be considered too low for infirm people, handles may be attached to the walls to assist in rising up.

Toilet paper should be used. In the first place it costs something, and this is a check on using an unnecessarily large quantity, which is an untidy and objectionable custom; secondly, it is preferable on the grounds of health, since printing ink has been found to be harmful by causing or aggravating local unhealthy bodily conditions.

It should be part of every child's education at home and at school to use the closet in the proper way, and to keep it scrupulously clean.

If people spent only one-tenth of the time attending to the excretory functions that they do to procuring and preparing their food they would be very much healthier.

The Earth for use in the closet should consist of dry garden mould, dry clay, brick earth, road dust, or soil in which grass or other vegetable life has existed. Sand and gravel are bad; chalk is not good. Wood ashes and coal ashes—not cinders—may be used. The amount of earth required is surprisingly small. Half a ton a year has been found ample for a family of seven or eight persons. The earth is sifted and stored under cover in quantity. Every time the closet is used a thin layer of earth is scattered over the excreta. The agricultural value of the product is lessened if much earth be used. The pail may be attended to daily or less frequently. If there is a garden belonging to the house, the contents may be buried in a shallow trench and covered in at once. If not, they may be put in some place under cover, turned over once or twice, and used again after a few weeks, even several times in succession. On the other hand, the sanitary authority of the district may collect the contents and take them to a piece of ground to be dealt with as a private individual would deal with them.

Under the Health Act of 1898, section 78, a local board of health in this State has power to undertake or contract for the removal of night-soil, and can make regulations requiring the occupiers of premises to provide proper receptacles in convenient plaecs, and forbidding anyone to deposit refuse or nightsoil in any other than the places they specify. Recent legislation empowers a local board to rate part of its district, say a seaside resort in a large country area, and to expend the money so raised in carrying out the sanitary administration of such a part. It may be said—in fact it is often said—that some people will

not take the trouble to use the earth closet as it ought to be used. That is quite true. Some people will not take the trouble to pull the chain of the water-closet cistern. That, however, is no reason why they should be allowed to have their closet in an offensive condition; and any person who permits such a place to become offensive—and offensiveness means neglect—is liable to a penalty of £20 under section 76 of the same Act.

If it should be found inconvenient to empty the pails of the earth closet as frequently as has been recommended, then a "dry catch" may be employed (see Fig. 4). In this the pail is dispensed with; the floor of the closet, which should be of smooth concrete, is made to slope slightly towards the ground outside; a trench is made to carry away or retain the urine, and the contents need not be removed for weeks or even months. When removed they are treated in the same manner as in the earth closet system.

A very compact and convenient form of portable earth closet, recommended by the State Board of Health of the Commonwealth of Pennsylvania, is shown in Fig. 5. It requires no explanation further than to say that the compartment for the pail should have no bottom. The cost of it is from 8s. to 12s. Such a closet can be placed and used anywhere indoors.

The burying of the contents of the pails or the "catch" should be done systematically in "garden ground." A trench is dug the width of an ordinary spade blade, and as deep as the blade is long. In this the contents of the pail are placed and are completely covered at once with earth so dug as to form a parallel trench at the distance of a spade's width from the first. The ground where the excreta have been buried should be planted with cabbage, onions, lettuce, spinach, or other such vegetables. The amount of land required for this sort of sanitation is not great; half an acre would be sufficient for a thousand people for a year.

Any ordinary form of cart is sufficient for the removal of the contents of the closet pans, and there is no objection to such removal being effected during the day. If a special cart should be preferred, as being useful for garbage and offensive matter, the pattern shown in Figs. 6 and 7 should meet all requirements. The receptacle is all iron, and is manipulated by a single screw.

It must be noted that this dry earth system of treating excreta is very different from a pail system in which no earth is used. In such a system—commonly known as the sealed pan or double pan system—the excreta very soon become offensive from decomposition, and cannot be utilised at once in the same fashion as when mixed immediately with dry earth. The nightsoil is generally buried deeply at a considerable distance from the township. The system is cumbersome, offensive, and wasteful; but in certain circumstances it is, unfortunately, the

only system applicable. There is not, however, in this State any city or township or country place in which it need be adopted. There exist everywhere throughout our State conditions that make the employment of the dry earth closet system quite practicable.

The earth closet costs less at first than the privy pit. The material removed can all be utilised without offensiveness, and at a profit to the farmer or gardener; hence there can be no excuse for not adopting the closet system. If it be said that it costs a great deal to fill up a privy pit and buy a pail, the reply is that it costs a great deal more not to do it. This is what Dr. Billings, a well-known American writer, says about a system of sanitation that is too common—"The cesspool is the chief reliance of the world at large. There is nothing to be said in its favor save what may be based on the old adage that 'what is out of sight is out of mind.' There is everything to be said in its condemnation, whether we regard its contents as a great mass of putrefying and infecting filth, as the source of oozings which travel through crevices of rocks, through layers of gravel, through seams in clay, or through lighter soils into and under cellars and into drinking-water wells and defectively-constructed cisterns, or as an ever-active gas retort supplying the pipes of the house with the foulest products of putrefaction. It is in all respects and under all circumstances a curse, unless placed far away from the possibility of tainting the air we breathe or the soil over which we live, or from which we or others take our drinking water, and even then it had better be abandoned."

Urine.—The treatment of this requires some notice. In the earth closet the urine may be separated from the excreta by a simple arrangement. In ordinary circumstances the quantity passed into the pail does not interfere with the proper treatment of the excreta. For larger quantities of urine, however, it is well to make separate provision. A "dry urinal" may be made of a receptacle containing sawdust or "chaff." The sawdust or chaff should be stirred up once a day. When this begins to be offensive, which may be in some months, it is ready to be used as manure. In this respect it differs from fresh sawdust, which makes bad manure. The urine in such urinals should never be diluted with water; and it should be remembered that a mixture of urine and soapy water, when allowed to stagnate, stinks vilely. Further, pure urine is too strong to be used continuously on a small piece of ground.

Kitchen and Pantry Slops.—These consist of water containing grease and suspended matter, bits of food, tea leaves, and such like materials. The method adopted by Dr. Poore, following recommendations by the Rev. Henry Moule, about 1866, for dealing with these slops, is as follows:—From the sink (which should not be made of lead, but of enamelled iron or earthenware) a pipe passes through and projects

beyond the wall of the house to a distance of about 18in., and at a height of 30in. above the ground. The slops run into a basket containing paper or a wisp of hay or grass, which acts as a rough but efficient strainer for fatty matter. Under this basket is a filter in duplicate, consisting of a box filled with broken clinker or gravel varying from the size of peas at the bottom to walnuts at the top. The outlet leads to a perforated iron gutter, which is flush with the surface of the ground and is supported at intervals by bricks in a trench filled with loose rubble, clinker, or such like material. The bottom of this trench slopes so that the slops may not flow towards the house. The surface of the gutter has a very slight fall. The perforations increase in diameter from the upper to the lower surface. Twelve feet of guttering should prove ample. The flow from the basket is so arranged that after one compartment of the box has been utilised as a filter for a few weeks the slops are directed into the other. The only attention the system requires is the renewal of the paper in the basket about once a fortnight, and keeping the gutter clear of leaves and other materials that would choke it. The filter-box may be considered a luxury ; if so, it may be replaced by an old pail with a hole in the bottom. Details of the scheme may be gathered from the drawing in Fig. 8. The cost is small (about 20s.), certainly very moderate for a system of sewerage.

Bedroom Slops.—These consist of urine and soapy water from the wash-basin. The water from the bath may also be included. Such slops may be run directly, without any straining or filtering, into a gutter scooped out with a garden hoe and conducted to a few square yards of garden bed or planted ground. The amount of land required for dealing with all slops is very small. It has been estimated at an acre for 7,000 persons, or little more than 6 sq. ft. for each. At Mannum, on the Murray, great difficulty was experienced in some cases on account of the houses being situated on a narrow strip between the cliffs and the main street, which was parallel to the river. Fig. 9 shows how part of a narrow lane between two houses was tilled and planted with greenery. This little strip proved sufficient for the needs of a household. In other cases a small patch of back or front garden proved ample.

Water from the bath should always be utilised for the garden or for similar purposes. The domestic waste of this water is very great. In a climate like ours a shower bath, which means a bucketful of water, is preferable to the plunge bath, which takes many gallons. When water is scarce even the shower bath may be dispensed with in favor of a towel-bath, made by dipping a bath towel in a basin of cold water, wringing it out, and rubbing the body all over with it. The action on the system is as good as, and in many cases better than, either the plunge bath or the shower. People waste water very thoughtlessly, and then when a drought comes they ask the clergy to pray for rain.

Canon Kingsley answered such thus: "Ere you ask for more rain, make places wherein you can keep it when you have it." The rebuke of a Bishop of Melbourne was, perhaps, more Australian in character. He is reported to have said, "What you people want is to pray less and dam more."

Garbage.—Under this term may be included all the refuse of the house and garden, such as remains of food, bones, rags, horn, leather, parings and waste pieces of vegetables, leaves, weeds, mowings of the lawn and sweepings of the walks. Whatever is useful for pig-feeding is placed in the pig bucket, which ought to be covered with a tight lid, in order not to attract flies. Other materials may be placed in a receptacle in the garden or elsewhere formed by a piece of rabbit netting and two or three uprights. Should the heap thus formed and accumulating begin to be offensive, a little earth scattered over it will put an end to the offensiveness. Pieces of glass and crockery, if broken up, form a good foundation for roads and garden paths; so also do coal cinders. "Green bones," either whole or broken down, if not too fatty, form good manure for the garden, and especially for orange trees, and give the trees a healthy, luxuriant appearance and improve the quality of the fruit. On the other hand, dry bones check the growth, and in some places owners have had to dig them up and remove them, with considerable trouble and at a good deal of cost. Bones do best on sandy and clayey soils and grass lands. On humid and calcareous soils they are of little use. Old tins may be utilised as flowerpots, or pounded down for foundations of roads or garden walks, or buried deeply. They should never be allowed to stand about, since they collect water, and thus form the breeding-grounds of numberless mosquitoes. Dry bones and shells of oysters and other shellfish should be burned, and the ashes used for manure. All these materials should be sorted out, and the receptacles for them kept tidy. Yards and gardens may be clean and yet far from clean-looking just on account of untidiness.

The sanitary apparatus required for use in the country is summed up in two words—*fire* and *soil*; the methods are strong burning and light burying.

Much has been written on the results of the dry earth system since it was first brought into prominence by the Rev. Henry Moule. A very extensive report was made to the Privy Council in England, in 1869, by Dr. Buchanan, the Medical Officer, regarding the practical working of the system in isolated cottages, public institutions, and villages. Dr. Corfield has discussed the *pros* and *cons* of the method in his book on "The Treatment and Utilisation of Sewage." The subject is referred to in nearly all standard works on hygiene, and there is a great deal of literature bearing upon it in reports of health authorities in the United States and elsewhere. Dr. Vivian Poore,

an ardent sanitarian, who was Professor of Medicine in University College, London, and for many years honorary secretary to the Parkes Museum of Hygiene, discusses the subject at length in three books*, in which he sets forth his practical experience as a sanitary reformer and property-owner in the country. He says—

"I have studied somewhat closely for the past 18 years the result of applying human fæces to a well-tilled humus, and I feel convinced that many who write upon the subject have taken but little pains to inform themselves as to the real facts.

"It will not be uninteresting, perhaps, if I give some of the results of my small experiment at Andover, which is now in its fourteenth year of trial. In this experiment the ordure and house refuse of about 100 persons have been removed and applied daily for gardening purposes. The amount now under the spade is exactly 1 acre 1 rood 7 poles, and I should like to say that the quantity of fæcal matter at the disposal of my gardener by no means satisfies him. I am also convinced that the garden might take, with advantage, at least double the quantity, if not more. There is no evidence, after a long experience, that the soil is overdone. On the contrary, its condition has steadily improved.

"In the middle of my garden is a well, which affords evidence that no fæcal matters are washed downwards to the subsoil water. This well, which was made mainly for experimental purposes, is very shallow, little more than a dip-hole. The bottom is $5\frac{1}{2}$ft. from the surface of the ground; the sides are lined with concrete pipes to the very bottom, and around these 4in. of concrete have been run in in order to give additional protection. There is a good parapet and a movable cover. The well was made in 1891, and the bottom and sides look as clean to-day as when they were made. No water can possibly enter this well except through the bottom, and I drink the water without any hesitation or misgiving, because I know there are no leaking sewers or cesspools in the immediate vicinity.

"I have said that this garden of $1\frac{1}{4}$ acres was manured with the refuse of about 100 persons for some years, and it may be stated that, proceeding methodically, it took four years to go completely over the whole of the ground in cultivation. The observer was usually astonished at the small amount of excremental material which has to be dealt with —not more, usually, than will lie in a furrow 10ft. or 12ft. in length made in the ground with a spade. Directly it is deposited in the furrow

* "Essays on Rural Hygiene," 3rd edition, 1903; "The Earth in Relation to the Preservation and Destruction of Contagia," 1902; "The Dwelling House," 1898.

it is lightly covered, and there is an end for ever of any offence or any danger. The first crop taken off the land is always a succulent green crop of the cabbage tribe, and the plants are dibbled in on the third day after the deposit. No other crops except cabbages seem to flourish in the fresh material, but the cabbages may be followed by potatoes, these by celery (planted between the rows), the celery by peas or beans, and these again by parsnips or carrots, without any fresh manuring, and with a most abundant yield. There is no doubt that this excremental refuse confers a fertility upon the soil which is not exhausted for years. I have been urged by some practical gardeners not to apply the material to the ground at once, but to store it in a heap with earth and ashes to allow it to 'ripen' before applying it. Those who give this advice have derived their experience from 'nightsoil' from privy pits which has undergone a certain amount of desiccation by the draining away of the fluid matter, and which is undoubtedly a most potent and dangerous manure when applied pure without previous admixture with earth and exposure to the air. By immediate burial before ammoniacal decomposition sets in there is no danger of this kind, and one is sure that nothing is lost. Further, if excrement be left above the ground, blowflies and other insects will deposit eggs in it, and then the gardener will complain that 'closet-earth brings grubs,' but by immediate burial this drawback is avoided. Many practical gardeners who have seen the results of the plan of operations which have been described have admitted that the results could scarcely be better than they are. Not only vegetables, but all the ordinary garden fruits are produced in high perfection."

Dr. George Keith, a shrewd practical Scottish physician, who travelled much of the world, saw a great deal, and lived to be over 90 years old, had much the same experience as Dr. Vivian Poore. After describing the simple earth closet, he says—

"In Algiers, where I followed the same plan for nearly a year and a half, during one summer and two winters, the whole mass was left quite near the house, exposed to sun and rain, and I often said that one might at any time have smoothed the surface, put a tablecloth over it, and eaten his dinner without being aware of any odor whatever. This is not, I acknowledge, a nice statement to make, but it certainly disposes of any possible objection that could be made on the score of health, or even of amenity. In India the dry earth system has long been in use; in the gaols it has been universally adopted. Colonel Cadell, late Governor of the Andaman Islands, where are the great penal settlements of the Indian Government, tells me it is used there with perfect success, and with great advantage in the raising of vegetable foods. On one occasion he was showing Admiral Fremantle over his command, and on Viper Island he took him into a large, long erection, and asked

him for what purpose he would suppose it was used. The Admiral looked round, and seeing nothing but that on both sides all along the apartment the space near the wall was divided into narrow sections by wooden partitions 3ft. high, he said that perhaps some of the convicts got their food there. He was amused to hear that the apartment had been used that morning by 500 convicts as an earth closet.

"From a sanitary point of view the dry earth system is perfect, and has been found to be so both in cold and in hot climates. It is surely worth something to those who adopt it to know that their own families run no risks from foul gases, and that they cannot contaminate their neighbors."

In India the method of superficial burying of nightsoil is now sanctioned by official regulation. Major A. C. Williams and Major D. J. Meagher have given a full account of the method as employed at Allahabad and elsewhere. They say that wherever the method is practised correctly it is sure to give every satisfaction, and where it is not working satisfactorily it is certain that the system has not been followed. Before the system was pronounced safe on sanitary grounds, many successful experiments were made by Surgeon-Colonel Martin, who was Principal Medical Officer of the Allahabad District at that time. The depositing grounds have been inspected by most of the medical, sanitary, and other scientific authorities in India, including the Principal Medical Officer of His Majesty's forces, all of whom have expressed their unqualified approval of the system.

The authorities there find from experience that this is the best known system for both wet and dry seasons. It has been carried out at Allahabad for 14 years without any hitch, and on various descriptions of soil, including stiff clay, black cotton, and even sand. Crops can be successfully grown immediately after burying, and even in the cultivation of grass the first crop is greedily eaten by cattle. Such land should be put down to grass without ploughing. Regulation compels the sowing of a sorghum or other crop on the land.

Enough has been said to show that the earth closet system is effective in all climates, and especially serviceable in warm countries where houses are surrounded each by its open space or garden plot, or where the conditions are such that a local authority can supply earth of the proper quality in necessary quantity, and arrange for the removal and disposal of the compost. In carrying out the system, and in judging of its success or deficiencies, it is necessary to remember what the system is: "*It consists in the application, with the greatest procurable detail, of dry earth to fresh human excrement, and in the subsequent removal and use of the mixture for agricultural purposes. In so far as detailed application is not made, or the earth is not dry, or the excrement not fresh, the dry earth system is departed from.*"

THE BACTERIOLYTIC TANK SYSTEM.

In discussing the subject of the natural decomposition of dung, excreta, and garbage, it was stated that the process was not a chemical, but a biological one, being due to the action of bacteria and other plants in the soil. The question naturally arises: Is the decomposition and consequent purification of sewage (*i.e.*, excreta, urine, &c., in water and not in contact with soil) due to the same or a similar cause? Experiment has shown that it is. Not only so, but it has been found that each stage in the decomposition is associated with different kinds of bacteria, following each other in a fairly regular succession.

The proposal to utilise the bacteria in the treatment of sewage was received at first with ridicule, and characterised as Satan casting out Satan! Nevertheless, some people who combine the practical and scientific in their inquiries, and keep their minds open to facts for and against, persevered in their endeavors to take nature into company instead of subjecting her to banishment.

It would be interesting, but not of much practical use for our present purpose, to review the many experiments made in sewage purification before a simple method was discovered of employing bacteria as natural scavengers. Experiments are still in progress, and much information is being gained with the view of finding the best methods of utilising the many varieties of bacteria, some of which do their work best when supplied with air, others when completely deprived of it. Experience has shown that systems of sewage treatment can be very expensive without being correspondingly useful, and that simple methods may be useful under a variety of conditions as to climate and composition of sewage. It will be best to give some selected examples of what has been done in South Australia in connection with this method of purifying sewage by bacteria, and to point out briefly the relation of these to the general theory and practice of what is commonly known as the Septic Tank System.* Be it understood, however, that the remarks apply primarily, not to towns possessing systems of sewerage on a large scale, nor to what is the best form of bacteriolytic tank system in any given case, nor to the science of bacteriolytic tanks in general, but to what has been done cheaply and effectively in this State in places where there is a limited quantity of sewage to be dealt with, an abundant water supply, and where a water-closet is preferred to a dry earth closet.

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* The word "septic" means pertaining to the decomposition of dead organic matter, with production of an unpleasant odor, due to various forms of bacteria. It has also become specially associated with the idea of disease. For these two reasons it is inapplicable and misleading in connection with sewage purification, and should be abandoned. The tanks are properly described as "bacteriolytic," which means breaking up materials by the action of bacteria.

In 1902 complaints were made regarding the sanitary arrangements at Gawler Railway Station. The water-closets, urinals, and sinks drained into a cesspool, 10ft. in diameter and 10ft. deep, immediately behind the station. This cesspool proved a source of offence to the residents of the station-house, and several of them suffered at various times from illnesses that were ascribed to insanitary conditions. The problem was how to put an end to the offensiveness, and to obviate the periodical nuisance and expense of having the cesspool emptied as frequently and in such a manner as the local authorities required. The problem was solved by converting the cesspool into a bacteriolytic tank system of two compartments and utilising the old effluent to carry away the final products.

The tanks were slightly offensive till a proper scum formed, which took about three months. Thereafter they were left absolutely untouched for over three years. In December, 1905, they were opened and inspected. There was no offensive smell. The scum in the tank was many inches thick and consisted of bluish-black, soft, homogeneous material.

At Kapunda Railway Station a similar cesspool was converted into a bacteriolytic tank system in 1903. It also was left untouched until December, 1905, when the tanks were opened and inspected. They were found to be working well, and they were quite free from offensive smell. The effluent was remarkably clear.

These two cases, it will be observed, were makeshifts. The form of the tanks and the relation of depth to surface were fixed to a certain extent by the necessities of the situation. This was not the case at the Glenelg Railway Station. There the tanks were erected as septic tanks from the beginning. They worked for years automatically and without offensiveness. The installation of a general bacteriolytic tank system for the town in 1905 made their employment no longer necessary. The formation of a scum on the new bacteriolytic tank was unusually rapid, the old tank furnishing the material for setting the process agoing.

An example on a smaller scale, one might say a domestic scale, may now be given. At Prospect, near Adelaide, Mr. A. W. Dunstone installed at his house a bacteriolytic tank system modified from a description published in the *Scientific American* supplement of October 17th, 1903. Two stout hardwood casks are used. (See Fig. 10.) One, the septic tank, is buried on end in the ground. This receives the contents from the water closet, the inlet being, as will be seen, about midway between its ends. It is ventilated at its upper end by a 1in. pipe. The second barrel is buried sidewise. The sewage passes from the first tank into this through a short connection, which has a com-

munication with the exterior for the purpose of inspection or removing the contents, if necessary, by pumping, in the event of the use of the apparatus being discontinued for a time. This cask has a grating of sticks which supports the filtering material and allows the incoming fluid to circulate freely below. The filtering material consists of broken stones, tiles, or gravel, about the size of hens' eggs, covered by rough gravel, about the size of chestnuts. The outlet from this cask is a bend leading to an old well 8ft. or 10ft. deep, from which the liquid soaks into the surrounding soil. In the original American design the liquid enters a flush tank, from which it is automatically discharged into a drain. Mr. Dunstone states that this installation has been in use for several years, and has worked well. The only attention it requires is an occasional clearing of the inlet pipe from paper at the entrance into the first tank by a rod passed through the plugged opening. This might be rendered unnecessary by having the bend less acute.

Other bacteriolytic tank systems are in use at railway stations and private houses of various sizes and at hotels throughout the State. It is unnecessary to describe them in detail. The principle of all of them is much the same as of those described.

Tank systems may be made with a couple of large drain pipes; and very large pipes, or complete tanks, made of reinforced concrete might prove very convenient and highly serviceable.

In Fig. 11 the plan and section of a tank system are shown. They represent all that is really essential in the structure of a bacteriolytic tank.

What happens in these tanks? After they have been in action for a varying length of time, if the first tank be examined there will be found on the top of the liquid a scum which goes on increasing in thickness to a certain limit, and in the bottom of the tank a quantity of sludge. This sludge and the under surface of the scum are the abode of multitudes of bacteria, which attack the solid parts of the sewage entering the tank and dissolve them. This integration and subsequent solution of the sewage is supposed to be carried on principally by bacteria that act without oxygen and in darkness, conditions that exist under the opaque and impenetrable scum in the first tank. When the sewage is thus broken down and liquefied it passes into the second tank, where further decomposition, involving oxidation and nitrification, occurs. This is supposed to be effected by bacteria working in a plentiful supply of oxygen and light. The final product is a liquid that is inoffensive to smell and even harmless to drink. Between these kinds of bacteria (called anaerobic) that work best in total darkness and without air and those (called aerobic) that work best with an abundance of both light and air there are many intermediate kinds. In the system of

tanks these are not marked off sharply from each other in the process of purification. One stage of decomposition overlaps another, and several species of bacteria will work simultaneously, though with varying degrees of activity. Many contrivances have been introduced to take advantage of the full working powers of the different species, such as passing the sewage over or through a succession of filters, or cultivation beds, each of which, on account of the kind of microbes growing in it, is particularly fitted to deal with a particular condition of the liquid.

Into the scientific details of these processes it is not necessary to enter. Probably if an abstract were made of all that is definitely known on the subject the statements would be considerably short of the truth. The aim in view in all variations of the apparatus is to purify sewage by natural means by using apparatus simple in construction and entirely automatic in action. As far as present knowledge goes, the results of experience may, for practical purposes, be summarised thus :—

1. The bacteriolytic tank should be lined with concrete and be capable of containing as nearly as possible 24 hours' sewage.
2. It is unnecessary to filter or otherwise separate the constituents of the sewage before it passes into the tank, unless a good deal of gravel, straw, wood, paper, or such like material is contained in the liquid.
3. The tanks may be opened or closed ; if closed the tanks should be so ventilated as to allow a constant supply of air to the second tank.
4. The syphon between the tanks and all other pipes in contact with the liquid contents, should be made of earthenware. Copper, zinc, lead, and iron, unless coated with tar, are all quickly decomposed.
5. The inlets and outlets should be so arranged as to allow the maximum of distribution with a minimum of movement of the fluid, and not to interfere with the surface scum.
6. Filtration materials may be employed or not in the second tank. They are said to act as cultivation grounds for the bacteria by furnishing a larger surface for their growth and action ; but experience in this State is against their use.
7. The resulting liquid may be passed on to the soil by gravitation or pumping, or allowed to soak into the subsoil by means of catch wells or drains.
8. Chemicals and disinfectants destroy the bacteria in the tanks and allow offensive putrefaction to take place.

On account of the difficulties connected with the working of certain kinds of tanks, and the failures and nuisances consequent on the neglect of some principles and details, it was found necessary to make regulations dealing with the structure and use of bacteriolytic tanks. The following are the regulations in force in this State :—

1. Plans and sections of all proposed tanks, with the connections thereof, shall be submitted to the Central Board of Health for approval before the tanks are constructed.

2. No person shall use any tank until a permit authorising him to do so has been issued by the Central Board of Health, nor shall he use any tank after such permit shall have been withdrawn or cancelled.

3. As far as possible, only the service of water-closets and urinals shall be connected with any tank.

4. No person shall allow any storm water or surface drainage to enter any tank.

5. All inlet pipes to a tank shall be properly trapped and ventilated.

6. Every tank shall be constructed of brick, lined with cement, or of some impervious material approved by the Central Board of Health.

7. Every tank shall be sufficiently covered to the satisfaction of the Central Board of Health.

8. Every tank shall be provided with a trapdoor of iron or slate or other stone, so disposed as to allow of ready inspection, and the connections between the trapdoor and the tank shall be airtight.

9. The aerobic portion of every tank shall be provided with an inlet and an outlet shaft of not less than 4in. in diameter for the purpose of ventilation.

10. All bends and connections of the tank shall be made of earthenware or of wood or other material suitably tarred.

11. No person shall allow any rubbish or insoluble matter to enter any tank, or to be deposited in the pan of any water-closet or urinal connected with the tank.

12. The effluent of every tank shall be so placed as to be easily accessible for inspection.

13. The permit to use any tank may be withdrawn by the Central Board of Health in its uncontrolled discretion.

14. Penalty for breach of any of these regulations, not exceeding £20; or, in the case of a continued breach, £2 for each day that the breach is continued.

Many causes may contribute to the failure of bacteriolytic tanks to work properly. These may be defects of management and defects of structure. The chief points to be noted are the following :—

Bacteriolytic tanks must not be expected to do work unconnected with sewage purification. They are not supposed to be disintegrators for all manner of rubbish or purifiers of offensive liquid that is not sewage.

The use of septic tanks at hospitals is in the experimental stage, and so far it has been found in practice almost impossible to attain good results on account of the difficulty of excluding antiseptics and disinfectants from the tanks. It must be remembered also that water from laundries is unsuitable in a tank system on account of the amount of antiseptics present in many soaps. Further, a large quantity of hot water will stop the working of a tank for some time.

The scum should be allowed to cover the whole of the water surface in the first tank, hence any form of pipe that projects through it should be disallowed.

The inlet pipe is subject to blocking from paper and other solids rising up when the inlet is directed straight downwards, and when pent up gas in an air-tight compartment forces this solid plug into the mouth of the pipe.

At certain seasons and under certain conditions the scum in the first tank forms a very thick layer—15in. to 18in.—and may block up the inlet pipe if it is too short, or grow over into the second tank if the partition is too low. The top of the partition should be not less than 12in. above the water level of the tanks.

The bend between the two tanks may become choked by solids or become impervious by an air-block. This may be obviated by drilling a small hole in its upper part, or by putting in two bends instead of one, or using only one half, as shown in the illustration. There are certain advantages to be gained by making the outlet pipe about 2in. below the level of the inlet.

One ventilator in a tank system is not enough. What is aimed at is a constant current of fresh air to supply oxygen to the second tank, not a single shaft to carry off smells which really do not exist. Two separate and independent ventilators are therefore essential, and both may be placed on the second tank, or one on each, provided there are openings over the top of the partition between the tanks. One ventilator may be a sort of "inset" on the ground level; the other should be higher. Great height, however, is not required—6ft. should be sufficient for all purposes. They should be about 4in. in diameter.

Fig. 12 shows the sort of plan that should be submitted in order to give an idea of the levels and connections of the drainage system connected with the tanks. It is reduced from an actual specimen sent for approval.

FIG. 1.

Fig. 2.

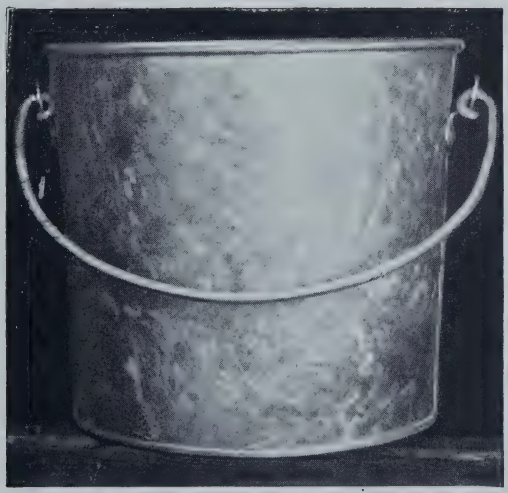


Fig. 3.

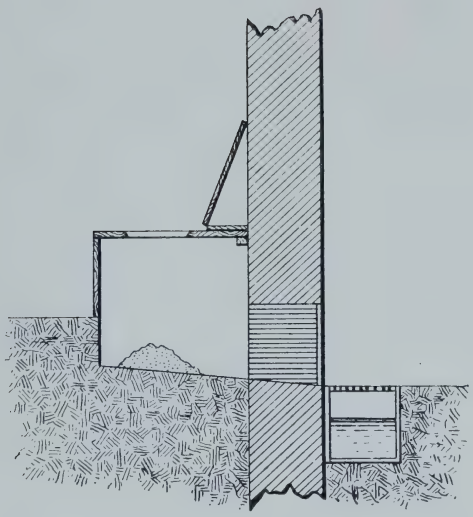


FIG. 4.

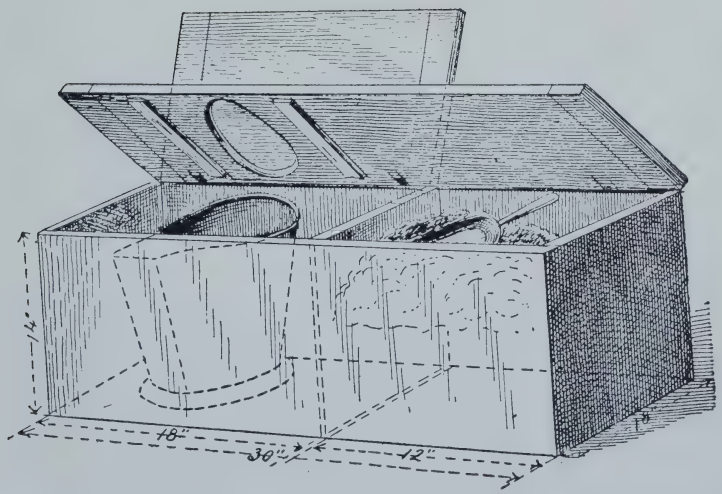


FIG. 5.

Fig. 6.

Fig. 7.

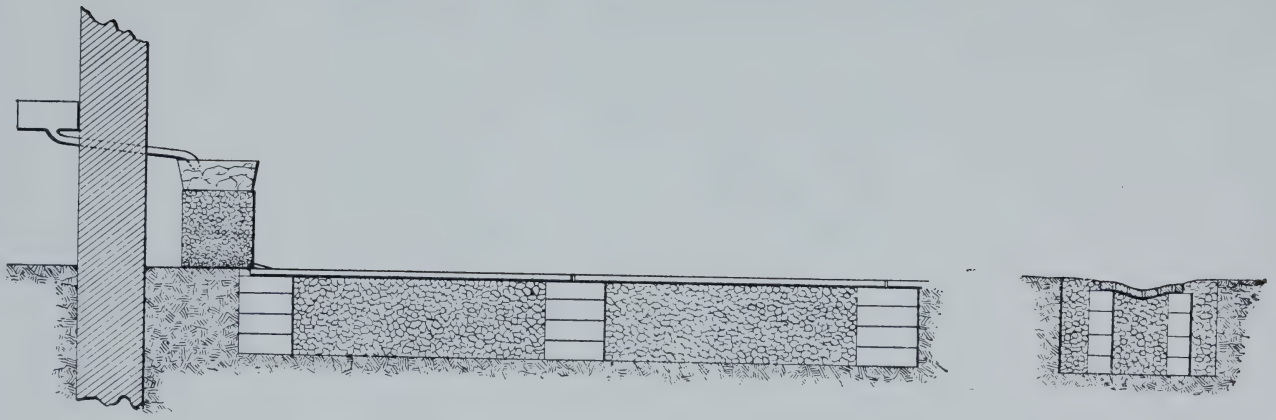


FIG. 8.

Filtration Gutter (after Poore).

Fig. 9.

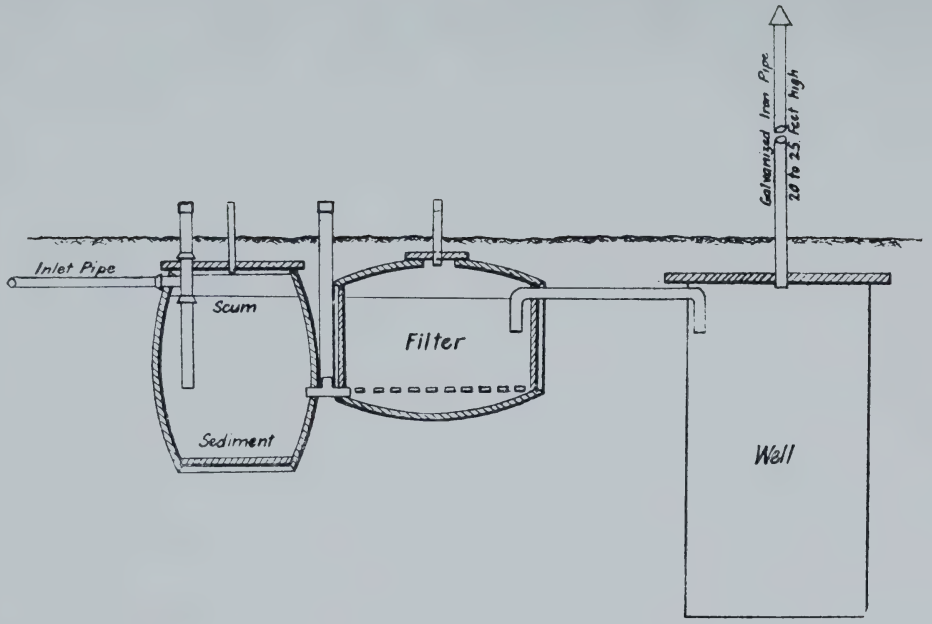

Galvanized Iron Pipe
20 to 25 Feet high
Inlet Pipe
Scum
Filter
Sediment
Well

Fig. 10.

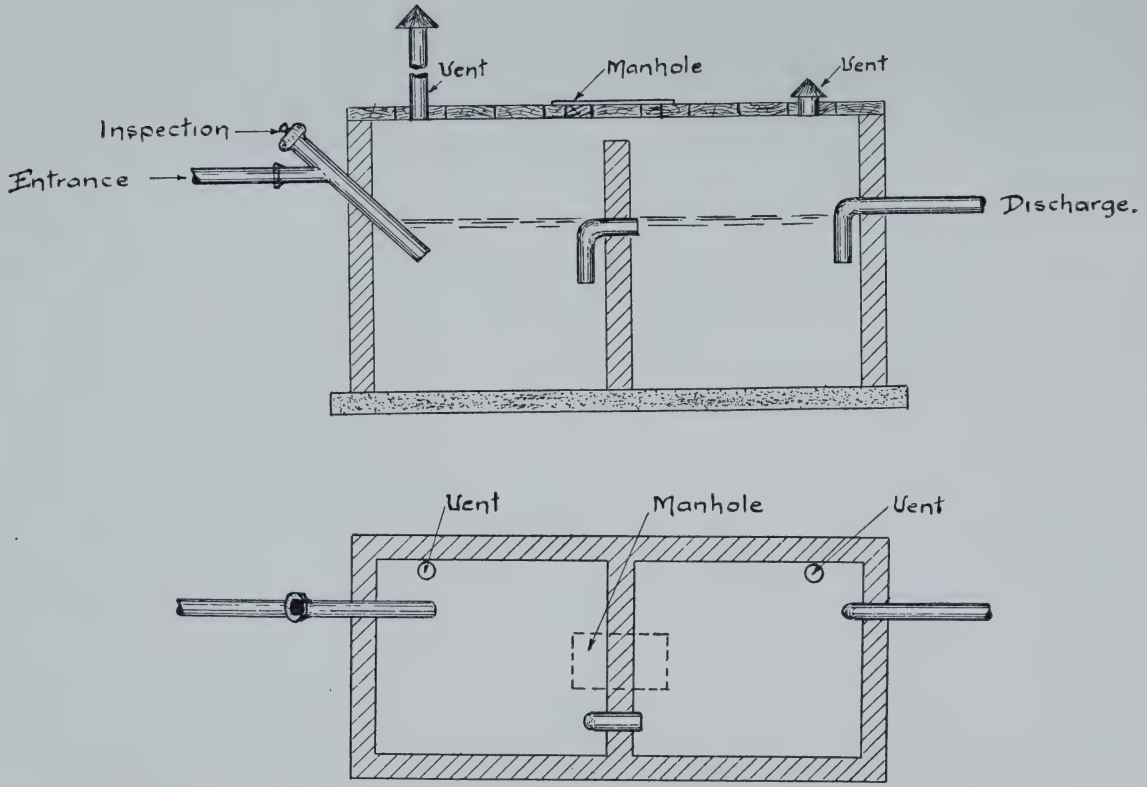
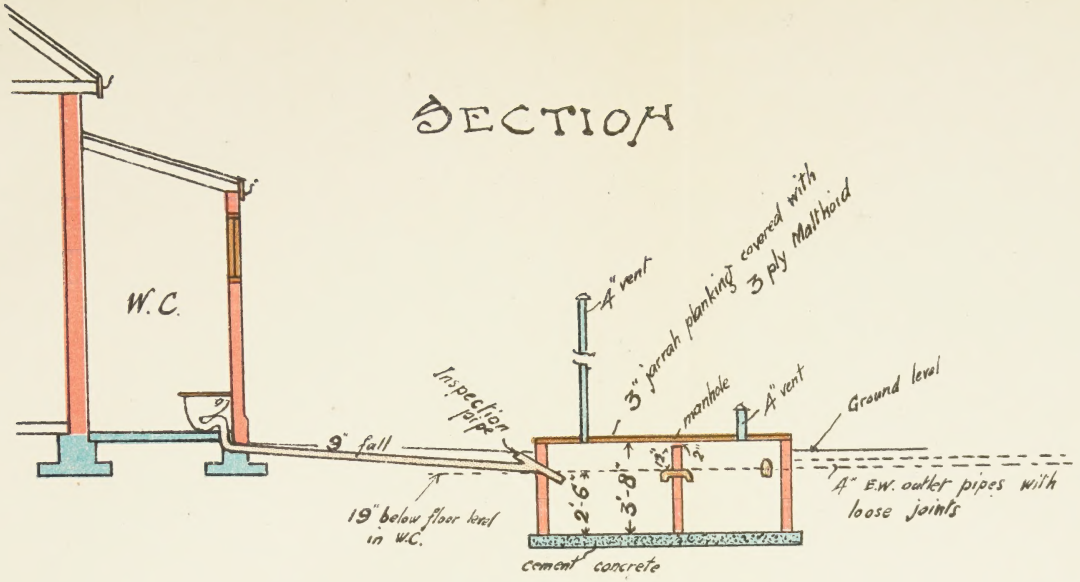
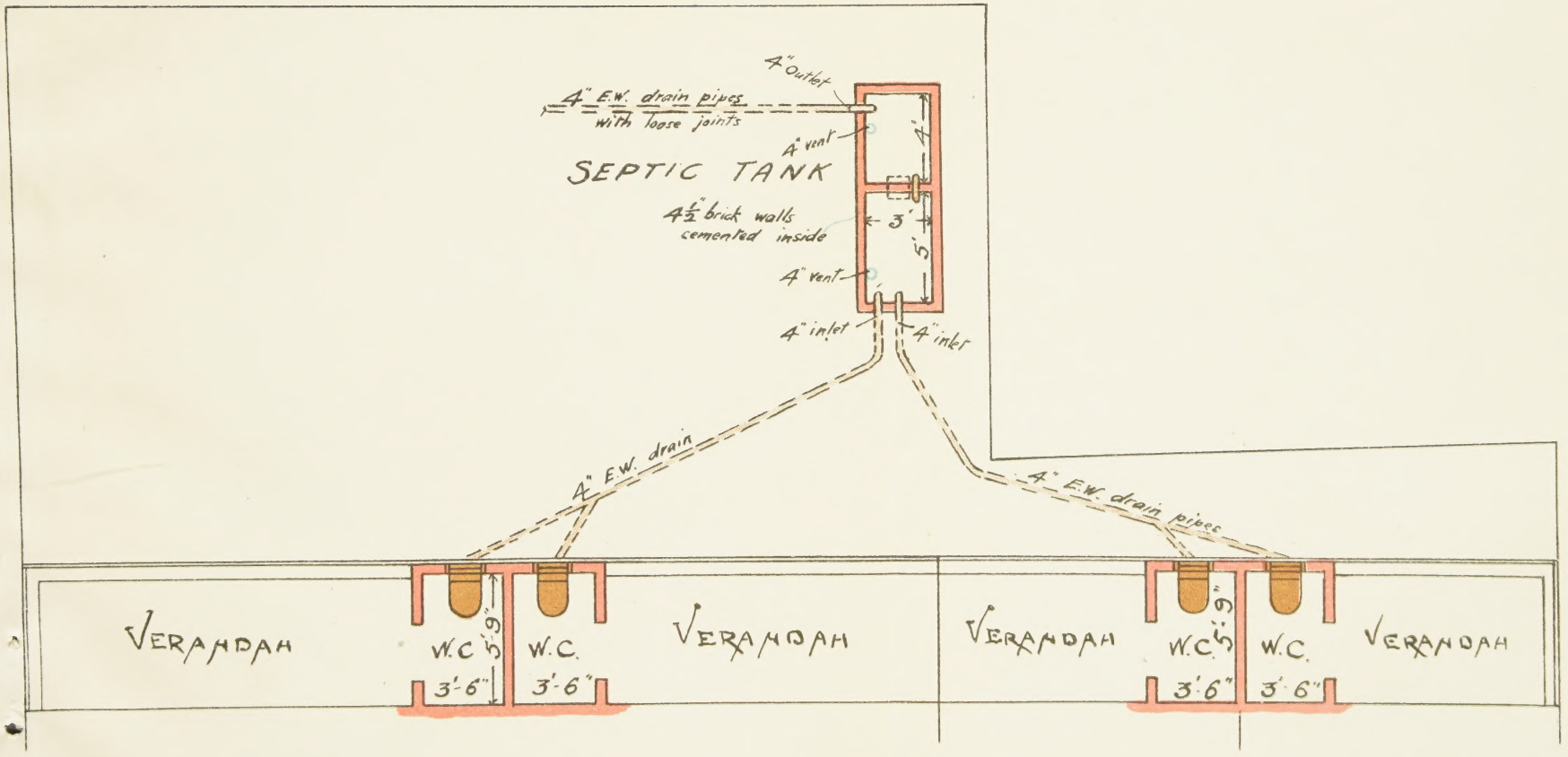

Vent
Manhole
Vent
Inspection
Entrance
Discharge.
Vent
Manhole
Vent

Fig. 11.

SECTION





SURVEYOR GENERAL'S OFFICE, ADELAIDE. A. Vaughan., Photo-lithographer